A DISSERTATION ON

RECONSTRUCTION OF FOOT - ANALYSIS OF 60 CASES

(M.Ch.,) Degree

BRANCH – III - PLASTIC SURGERY

THE TAMILNADU
DR.M.G.R. MEDICAL UNIVERSITY

CHENNAI, TAMILNADU

AUGUST 2009

DEPARTMENT OF PLASTIC SURGERY
MADURAI MEDICAL COLLEGE
MADURAI

CERTIFICATE

This is to certify that this dissertation entitled "**RECONSTRUCTION OF FOOT – ANALYSIS OF 60 CASES**" submitted by DR.KANNAN PREMA to the faculty of Plastic Surgery, The Tamil Nadu Dr. M.G.R. Medical University, Chennai, in partial fulfilment of the requirement in the award of degree of MASTER OF CHIRURGIE IN PLASTIC SURGERY, Branch – III, for the August 2009 examination is a bonafide research work carried out by her under our direct supervision and guidance.

PROF. DR.C.BALASUBRAMANIAN M.S., M.Ch.,

Prof. and Head of the Department
Department of Plastic Surgery,
Govt. Rajaji Hospital &
Madurai Medical College,
Madurai, TamilNadu, India.

DECLARATION

I, Dr. KANNAN PREMA solemnly declare that this dissertation titled "**RECONSTRUCTION OF FOOT – ANALYSIS OF 60 CASES**" has been prepared by me.

This is submitted to The Tamil Nadu Dr. M.G.R. Medical University, Chennai, in partial fulfillment of the requirement for the award of MASTER OF CHIRURGIE, M.Ch., PLASTIC SURGERY, degree Examination to be held in AUGUST 2009.

Place : Madurai

Date : Dr.KANNAN PREMA

ACKNOWLEDGEMENT

I thank our respected Dean of Madurai Medical College for permitting me to use the hospital facilities for this study.

I am very grateful to my humble enthusiatic teacher, advisor Prof. Dr.C. BALASUBRAMANIAN, M.S.,M.Ch. Professor and Head of Department of Plastic Surgery for his constant guidance, encouragement and enthusiasm throughout the period of this study.

I express my respect and thankfullness to Prof. V. NARAYANAN Prof A. CHARLES for helping me sail smooth the journey of study.

I am indebted to Prof.V.DEVASENAN for the guidance, suggestion and comments given during the study.

I deeply express my love, affection and gratitude to all the Assisstant Professors in our department - Dr. R. Raja Muthiah, Dr.S.Gnanasekaran, Dr.S.Aram, Dr.P.Suresh, Dr.V.Ravichandran, Dr.P.Parthasarathy for their crictics suggestion guidance execution and assisstance thoughout the study course, helping me sail steady.

I sincerely thank my patients and peers without whom this study would not have been possible.

I express my thanks to my colleagues who helped me during this study.

Above all I thank my PARENTS and ALMIGHTY for the blessings they have showered upon me in all the deeds of life.

CONTENTS

INTRODUCTION

Reconstruction of foot is an area of formidable challenge due to the innate nature of the coverage tissues, sensation and vascularity. Various options are available, each has its advantages and disadvantages. In this study pros and cons of each reconstruction done in our hospital analyzed.

Weight-bearing areas of the foot still represent one of the most difficult options for the plastic surgeon because of the unique mechanical properties of the sole of the foot. Reconstruction of non-weight-bearing areas such as the instep, the dorsum of the foot, or the ankle area, is also demanding because the reconstructed parts have to withstand mechanical stress from shoes and walking-boots.. A wide variety of flaps available now facilitates an “optimal” solution for each patient including parameters, such as social and medical profile, body constitution, or donor site morbidity.

Careful planning of reconstructive options from the most simple to the more complex should be within the armamentarium of the reconstructive surgeon's expertise. The simplest reconstructive method is still the best technique. There will always be instances where a more complex reconstruction will be needed, and with the advances in microsurgery larger defects can be reconstructed and restore function after tumor ablation. By using a standardized functional outcome assessment the best reconstructive option for the patient can be determined.

HISTORICAL REVIEW

The history of lower extremity reconstruction before World War I is essentially the history of amputation and generally centers on war injuries and their management. Advances in wound care achieved in the ancient world were lost with the fall of the Roman Empire. With the Renaissance, science and medicine again began to advance.

Ambroise Pare (1509-1590) described and performed the basic rules of amputation by recommending amputation through viable tissue and closure of amputation stump to fit prostheses. He reintroduced the use of hemostatic ligature developed by Celsus (25 B.C. – 50 A.D) but long abandoned. Andreas Vesalius published the anatomy text De Humani Corporis Fabrica' in 1543 and William Harvey published 'Exercitatio Anatomica de Motu Cordis et sanguinis in Animalibus in 1628. These laid the foundation for future studies on the functional anatomy of the vascular system.

John Hunter (1728-1793) highlighted the vascular functional anatomy and the importance of anastomotic vessels around the knee. It was the first description of surgical delay.

Pierre-Joseph Desault (1744-1795) coined the term ‘debridement’ and advocated it in traumatic wounds. Ollier (1830-1900) introduced the concept of immobilisation and developed the plaster cast.

World War I marked a turning point in wound management and trauma surgery. Carrel-Dakin method of wound irrigation was popularised. H. Winnett Orr introduced closed plaster technique.

In the Spanish civil war (1936-1939), Joseph Trueta advocated thorough wound debridement before cast application. Improvement in aseptic techniques and antibiotics decreased the mortality through wound complications from 8% in World War I to 4.5% in World War II.

The concept of arterial repair was introduced during the Korean conflict (1950-1953). Vascular surgical techniques were applied in 1960s with the use of microscope thus sparking the modern era of microvascular reconstruction that continues to this day.

Evolution of flaps

The history of development of flaps can be divided in the following phases.

- An early period spread over various centuries from Susruta 700 B.C. to the First (1917) and Second (1942) World Wars.

- The second period during 1950s and 1960s – discovery of regional axial pattern flaps.
- The third period during 1970s, the muscle and musculocutaneous flaps were developed with simultaneous development of free tissue transfer. Differences between axial and random pattern flaps were studied elaborately during this period.
- The fourth period during 1980s the fasciocutaneous flaps were scientifically developed and clinically applied extensively. During the same period there was further development and clinical application of wide range of free flap transfer.

The fifth period during 1990s, the neurocutaneous flaps were described in legs. Then perforator based flaps were described, improving complicated management of lower limb defects

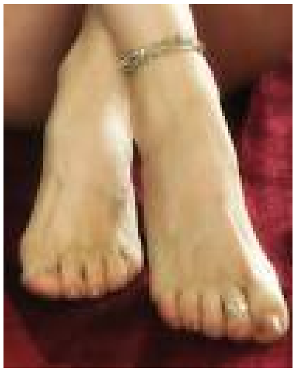
AIM OF STUDY

The aim of this clinical study

1) To study the age and sex incidence
2) To study the etiological factors responsible for the soft tissue defect of the leg.
3) To study the anatomical site of soft tissue defect.
4) To study the type of soft tissue reconstruction done.
5) To study the duration of hospital stay for the procedure
6) To study follow up – sensation, pliability and contracture
7) To compare skin graft vs. flap in foot reconstruction.

REVIEW OF LITERATURE

Anatomy of foot

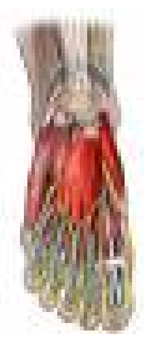


Dorsum

<u>Skin</u>:

It is thin, hairy and freely mobile

<u>Nerve supply:</u>



The superficial peroneal nerve is between the peroneus brevis and extensor digitorum longus. Its medial cutaneous branch supplies dorsum of the foot, medial side of the big toe and adjacent sides of 2nd and 3rd toes. The lateral branch supplies the dorsum of the foot and adjacent sides of the 3rd to 5th toes. The deep peroneal nerve supplies the adjacent sides of 1st and 2nd toes. The Saphenous nerve supplies the medial side of the foot as far forward as the head of the 1st metatarsal bone. The Sural nerve supplies the lateral side of foot and the 5th toe.

Dorsal venous arch:

It lies in the subcutaneous tissue over the heads of the metatarsals and drains medially into the great Saphenous vein and laterally into the small Saphenous vein. The great Saphenous vein ascends in the leg in front of the medial malleolus. The small Saphenous vein is behind the lateral malleolus.

Muscles of the dorsum of the foot:

Extensor digitorum brevis.:

This fleshy belly arise from upper surface of calcaneum and deep surface of the stem of Y-shaped inferior extensor retinaculum. It passes obliquely across dorsum of the foot and gives four tendons to medial four toes.

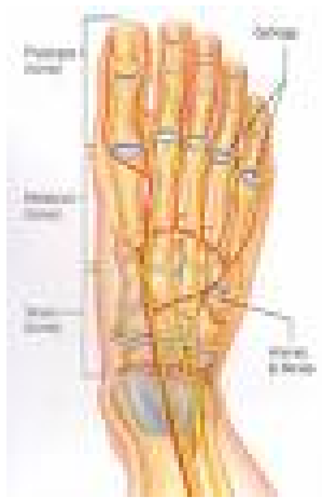
Extensor hallucis brevis

The tendon to great toe is different from others and named as extensor hallucis brevis. Its belly separates early from main muscle mass of extensor digitorum brevis and inserted separately into base of proximal phalanx of great toe.

Long extensor tendons.

These pass behind the superior and through the inferior extensor retinacula. The tendon divides into four which fan out and pass to the lateral 4 toes. Opposite the 2nd to 4th MP joints, each tendon is joined laterally by a tendon of extensor digitorum brevis. On the dorsum of each toe, each tendon joins the extensor expansion. At the PIP it divides into a central part which is inserted in the base of the middle phalanx and two lateral parts which converge to insert in the distal phalanx.

Arteries of the dorsum of the foot:



Dorsalis pedis artery is a continuation of the anterior tibial artery. It terminates by passing into the sole between the two heads of 1st dorsal interosseous muscle to form the plantar arch. It is medial to the deep peroneal nerve and extensor digitorum longus tendon and lateral to extensor hallucis longus tendon. Lateral tarsal artery crosses the dorsum of the foot just below the ankle joint. Arcuate artery runs laterally under the extensor tendons and give off metatarsal branches to the toes. First dorsal metatarsal artery supplies both sides of the big toe.

The sole of the foot:

Skin:

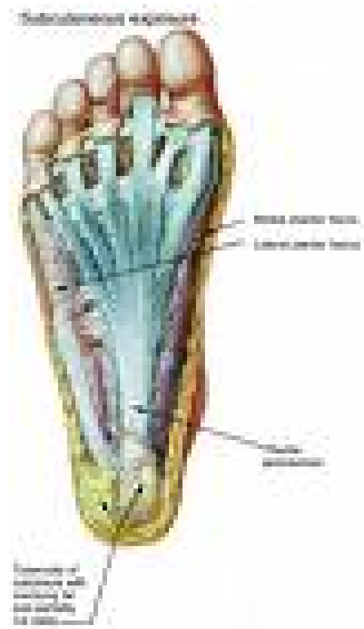
The skin of the sole of the foot is thick and hairless with abundant sweat glands. It is firmly bound down to the underlying deep fascia by numerous fibrous bands. It shows few flexor creases at the sites of skin movement. The subcutaneous tissue contain a lot of fat, especially the heel of foot.

Nerve supply:

The sensory nerve supply of the heel is by the medial calcaneal branch of tibial nerve. Medial 2/3 of the sole is supplied by the medial plantar nerve while the lateral 1/3 by the lateral plantar nerve.

Deep Fascia:

The deep fascia is thickened to form the flexor retinaculum and the plantar aponeurosis.



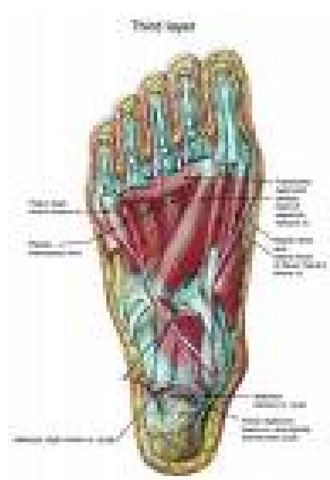
The flexor retinaculum extends from the medial malleolus downwards and backwards to be attached to the medial surface of the calcaneum. It binds the tendons entering the foot behind the medial malleolus to the medial side of the ankle.

The plantar aponeurosis is triangular in shape and occupies the central area of the sole. The apex is attached to the medial and lateral tubercles of the calcaneum. It divides at the base of the toes into five slips. Each slip further divides into the superficial band to the skin and a deep band passing to the root of the toes, where it divides into two, diverging along the flexor tendons and fusing with the fibrous sheath and the deep transverse ligaments.

The medial and lateral borders of the thick aponeurosis are continuous with the thinner deep fascia covering the abductors of the big and little toes. From each of these borders, fibrous septa pass superiorly into the sole and take part in the formation of the fascial spaces of the sole.

The function of the plantar aponeurosis is to give a firm attachment to the overlying skin, to protect the underlying vessels, nerves and tendons and their synovial sheaths, and to assist in maintaining the arches of the foot.

Muscles of the sole of the foot:



First layer.

Abductor hallucis.

Flexor digitorum brevis.

Abductor digiti minimi.

Second layer:

Quadratus plantae.

Lumbricals.

Flexor digitorum longus tendon.

Flexor hallucis longus tendon.

Third layer:

Flexor hallucis brevis.

Adductor hallucis.

Flexor digiti minimi brevis.

Fourth layer:

Interossei.

Peroneus longus tendon.

Tibialis posterior tendon.

Fibrous flexor sheaths

The inferior surface of each toe is provided by a strong fibrous sheath, which is attached to the side of the phalanges. Their proximal ends receive the deeper parts of the slips of plantar aponeurosis while their distal ends are closed and are attached to the base of the distal phalanges. They contain the tendons of flexor hallucis longus in the big toe and tendons of flexor digitorum longus and brevis in the other 4 toes.

Synovial flexor sheaths:

The tendon of the flexor hallucis longus is surrounded by the synovial sheath which extends upwards behind the medial malleolus above the flexor retinaculum. This ends distally at the base of the first metatarsal bone. The tendon acquires a digital synovial sheath in the osteofibrous canal.

The tendons of flexor digitorum longus also have synovial sheaths which extend above the flexor retinaculum. Distally they extend as far as navicular bone, and acquire a digital synovial sheath in the osteofibrous canals.

Arteries of the sole of the foot

Medial plantar artery:

It is the smaller of the terminal branches of the posterior tibial artery. It passes forward deep to the abductor hallucis medial to the medial plantar nerve. It supplies the medial side of the big toe.

Lateral plantar artery:

It is the larger of the terminal branches of the posterior tibial artery. It passes forward deep to the abductor hallucis and flexor digitorum brevis lateral to the lateral plantar nerve. It curves medially at the base of the 5th metatarsal to form the plantar arch which joins the dorsalis pedis artery in the 1st intermetatarsal space. The plantar arch gives off plantar digital arteries.

Dorsalis pedis artery:

It enters the sole between the two heads of the 1st dorsal interosseous muscle and joins the plantar arch. It gives off the 1st plantar metatarsal artery.

Nerves of the sole of the foot

Medial plantar nerve:

It is the terminal branch of the tibial nerve. It supplies abductor hallucis, flexor digitorum brevis, and 1st lumbrical muscles. Plantar digital nerves are its cutaneous branches which supply the skin over the medial 3 and one-half toes, the nail beds and tips of the toes.

Lateral plantar nerve:

It is also a terminal branch of the tibial nerve. At the base of the 5th metatarsal it divides into the superficial and deep branches. It supplies the quadratus plantae and abductor digiti minimi and cutaneous branches to the lateral part of sole. The superficial terminal branch supplies the flexor digiti minimi and interosseous muscles of 4th space. The plantar digital branches supply the lateral one and half toes, nail beds and the tips of the toes. The deep terminal branch supplies the adductor hallucis, 2nd to 4th lumbricals, and all the interossei except the 4^{th} interossei.

Causes of Soft tissue defect of foot

1. Congenital
2. Acquired
    a. Trauma
    b. Burns
    c. Tumor
    d. Infection
    e. Vascular Disorder
    f. Peripheral Neuropathy
    g. Immunological Disorder
    h. Lymphatic Disorder
    i. Ischemia
    j. Tropical Disorder

Evaluation

Evaluation of the patient with a foot wound or ulcer begins with a complete history and physical examination. Important points in the history include etiology, duration and previous treatment of the wound(s), co morbid conditions (diabetes, peripheral vascular disease, venous insufficiency, atherosclerotic disease, autoimmune disorders, radiation, coagulopathy, etc), current medications, allergies, and nutritional status. It is also important to assess the patient's current and anticipated level of activity.

The complete physical examination starts with a careful wound measurement (length, width, and depth), as well as the type of tissue, fascia, tendon, joint capsule, and/or bone. The levels of tissue necrosis and possible avenues of spread of infection via flexor or extensor tendons are then determined. If cellulitis is present, the border of the cellulitis is delineated with a marker and the date and time are noted. This permits the clinician to immediately monitor the progress of the initial treatment despite the lack of bacterial culture results.

The vascular supply to the foot is then examined. If pulses are palpable (dorsalis pedis or posterior tibial artery), there is usually adequate blood supply for wound healing. If one cannot palpate pulses, a Doppler should be used. The Doppler ultrasound probe also allows the surgeon to evaluate the non palpable anterior perforating branch and the calcaneal branch of the peroneal artery. It also helps determine the direction of flow along the major arteries of the foot to accurately assess local blood flow when designating a flap or amputation. A triphasic Doppler sound indicates excellent blood flow; and a monophasic sound warrants further investigation by the vascular surgeon. A monophasic tone does not necessarily reflect inadequate blood flow as it may reflect of lack of vascular tone and absent distal resistance.

If the pulses are nonpalpable or monophasic, then noninvasive arterial Doppler studies are indicated. It is important to obtain PVRs (pulse volume recordings) at each level because arterial brachial indices are unreliable in patients with calcified vessels. Ischemia may be present if the PVR amplitude is < 10 mm Hg.

Sensory exam is performed with a 5.07 Semmes-Weinstein filament that represents 10 g of pressure. If the patient cannot feel the filament, protective sensation is absent, leading to an increased risk of breakdown. Motor function is assessed by looking at the resting position of the foot and the strength and active range of motion of the ankle, foot and toes.

The bone architecture is evaluated by looking at whether the arch is stable, collapsed, or disjointed. Bone prominence can occur with collapsed midfoot bones (cuboid or navicular bone with Charcot destruction of the midfoot), osteophyte formation, or abnormal biomechanical forces (hallux valgus, hammer toe, etc).

Finally, the achilles tendon should be evaluated. If the ankle cannot be dorsiflexed 10 to 15 degrees above neutral, the Achilles tendon is tight and is placing excessive stress on the arch in the midfoot and on the plantar forefoot during gait. This necessitates release so as to avoid excessive pressure that could lead to Charcot collapse or forefoot plantar ulceration.

Preparation of Wound for Reconstruction

The goal to treating any type of wound is to promote healing in a timely fashion. The first step is to establish a clean and healthy wound base. An acute wound is defined as a recent wound that has yet to progress through the sequential stages of wound healing. If the wound is adequately vascularised, a clean base can be established with simple debridement and either immediate closure or covering the wound with a negative-pressure closure device (a vacuum-assisted closure (VAC) device) for subsequent closure. A chronic wound is a wound that is arrested is one of the wound-healing states (usually the inflammatory stage) and cannot progress further. Converting a chronic wound to an acute one requires correcting medical abnormalities (high blood sugar levels, coagulation abnormalities, changing or modifying drug therapy, etc), restoring adequate blood flow, administering appropriate antibiotics if any infection is present, and debriding the wound aggressively. If the wound has responded to this aggressive therapy, healthy granulation should appear, edema should decrease, and neoepithelialization should appear at the wounds edge. The VAC device is a useful postdebridement dressing for the well-vascularised wound because it decreases wound edema, helps to keep the bacterial count down, and promotes the formation of granulation tissue.

Surgical debridement is the single most underperformed procedure in treating foot and ankle wounds and ulcers because of concerns of how to close the resultant defect. Leaving dead or infected tissue or bone behind because of concerns about wound closure leads to subsequent infection and possible amputation.

The most effective debridement technique consists of removing thin layers of tissue in a sequential fashion until only normal tissue is left behind. This minimizes the amount of viable tissue sacrificed while ensuring that the tissue left behind is healthy. An effective alternative debriding device is a high pressure water jet (up to 15,000 lb of pressure per square inch) that removes serial layers of tissue.

The skeleton can usually be stabilized by splinting or corrected by application of an external fixator (monoplanar frame, Ilizarov frame). The Ilizarov frame provides superior immobilization, allows for bone transport and minimizes the risk for pin track infection because of the thin wire pins.

Deep uncontaminated tissue cultures should be obtained during the initial and subsequent debridements to guide antibiotic therapy (both intravenous and topical). Effective dressings for wounds that may still harbor significant bacteria are an appropriate topical antibiotic, a silver ion sheet, or antibiotic impregnated methylmethacrylate beads covered with an occlusive dressing. For heavy exudative wounds, an absorbent dressing with bactericidal ingredients used. For wounds that are clean and well vascularised, moist dressing or the VAC can be applied.

Finally, systemic hyperbaric oxygen can also be used to convert a nonhealing wound into a healthy granulating wound. It stimulates local angiogenesis in the wound bed, helps in the formation of collagen, and potentiates the ability of macrophages to kill bacteria.

RECONSTRUCTION LADDER

Reconstruction is guided by the principle that coverage of a wound should be performed as quickly and efficiently as possible. Once the wound is clean and well vascularised, a reconstructive option is chosen from the reconstructive ladder:

(a) Allowing the defect to heal by secondary intention.

(b) Closing the wound primarily.

(c) Applying a split- or full – thickness skin graft.

(d) Rotating or advancing a local random flap.

(e) Regional Flaps

Rotating a pedicled flap.

Perforator Based Propeller Flap

(f) Transferring a microvascular free flap.

The solution is guided by the patient's health, the depth of the wound, the location of the wound, and the surgeon's experience. The solution must always include restoration of a biomechanically sound foot to prevent recurrent breakdown.

Useful guidelines suggest simple coverage (secondary intention, delayed primary closure, or simple skin graft) if there is not tendon, joint or bone involved. Even more complex wounds involving exposed tendon, joint, or bone that mandated flap reconstruction in the past can now be treated with simpler methods. For example, wounds over the achilles tendon easily develop adequate granulation tissue with good wound care that can then be simply covered with skin graft. With the VAC, granulation tissue can form over tendon, bone, or joints that can then heal either by secondary intention or be skin grafted.

Biomechanics are a critical part of the reconstructive plan and may involve bone rearrangement, partial joint removal or fusion, or tendon lengthening or transfer. The method of soft tissue reconstruction chosen hinges on the surgeon's experience, the size of the wound, the vascular status of the foot, the exposed structures (tendon, joint, and/or bone), and the access to the wound (ie., and Ilizarov frame limits the access to the foot).

Secondary Intention:

Wounds can be allowed to heal by secondary intention with daily dressing changes, application of the VAC, and/or correction of the biomechanical abnormality. A tight achilles tendon is the principal cause of forefoot plantar ulceration in diabetics. By simply lengthening the tendon, the plantar wound usually heals without further treatment over the next 6 weeks. The application of growth factor or cultured skin can speed up healing by secondary intention.

Delayed primary closure

Delayed primary closure is easier to accomplish when the edema and induration of the wound edges has resolved. The VAC can be helpful in reducing the edema by absorbing all excess fluid. After primary closure, one should always check that relevant arterial pulses have not diminished because of an excessively tight closure. If the gap is too large to allow for immediate closure of the defect, the wound can be closed serially or the remaining gap can be treated to heal by secondary intention. Adequate soft-tissue envelope can also be created by removing underlying bone.

Skin grafting

Skin grafting can be used to close most foot and ankle wounds. A healthy granulating bed is the necessary prerequisite. This can be achieved by the methods delineated above and include VAC, cultured skin, dermal regeneration template, growth factor, and/or hyperbaric oxygen. Successful skin graft take is aided by removing the granulation bed that contains bacteria before placing the skin graft. The skin graft is meshed at a 1:1 ratio to prevent build up of seroma or hematoma.

If the skin graft is over moving muscle or joint, it is critical to immobilize the foot and ankle by splinting or placement of an external fixator until the skin graft has completely healed. The ideal graft donor site for a plantar wound is the glabrous skin from the plantar instep because the thicker glabrous skin graft resists the shear forces applied to the plantar foot during ambulation. It is harvested at $30/1000^{th}$ of an inch, meshed, and covered with a VAC. The donor site is, in turn, covered with a thin skin graft of $10/1000^{th}$ of an inch. For plantar wounds where the patients is noncompliant whether by choice or because of body habitus, consideration is given to placing an Ilizarov frame with protective foot plate until the graft has healed.

Local Flaps

Local flaps are useful in coverage of foot and ankle wounds because they only need to be large enough to cover the exposed tendon, bone, or joint while the rest of the wound's skin grafted. This frequently obviates the need of larger pedicled or free flaps. In addition, an infinite variation of local flaps can easily be done around or through an Ilizarov external fixator because the lack of access makes pedicled flaps or free flaps hard to carry out.

a. Transposition and Rotation Skin Flaps of the Sole of the Foot.
b. Bipedicle Skin Flap to the Heel
c. V-Y advancement Flaps to the Heel and Ankle
d. Deepithelialised "Turnover" Skin flap of the lower Leg and Foot
e. Reversed Dermis Flap of foot and heel
f. Filleted Toe Flap
g. Medial Plantar Flap

h. Lateral Calcaneal Artery Skin Flap
i. Plantar Artery – Skin – Fascia Flap
j. Medial Plantar Flap
k. Lateral Supramalleolar Flap
l. Dorsalis Pedis Flap
m. Dorsalis Pedis Myofacial Flap
n. Medialis Pedis Flap
o. Abductor Digiti Minimi Muscle Flap
p. Abductor Hallucis Brevis Muscle Flap
q. Flexor Digitorum Brevis Muscle Flap
r. Flexor Hallucis Brevis Muscle Flap
s. Extensor Digitorium Brevis Muscle Flap
t. Flexor Hallucis Brevis Muscle Flap

Pedicled flaps

Pedicled flaps in the foot and ankle area are often more difficult to dissect and have a higher preoperative complication rate, although equal long-term success, as free flaps. However pedicled flaps allow the surgeon to perform a rapid operation with a short hospital stay that yields long-lasting results.

a. Lateral Supramalleolar Flap
b. Posterior Calf Fasciocutaneous Flap with Distal pedicle to Reconstruct Ankle
c. Cross – Foot Skin Flap
d. Cross – Thigh Flap
e. Cross – Groin Skin Flap
f. Buttock Skin Flap
g. Ipsilateral Gracilis Musculocutaneous Flap
h. Gastrocnemius Musculocutaneous Cross – Leg Flap
i. Distally based sural artery Flap

Propeller Flap

Based on a single competent perforator, Flap markings made – islanded and rotated 180° after skeletonizing the perforator for about 2 to 4 cms. Flap dimensions vary from 1:5 to 1:10.

Free Flaps:

Free flaps in the foot and ankle carry the highest failure rate in the microsurgical literature and should be planned carefully. One reason for this is that complications arise when the anastomosis is performed at or near the zone of injury. In addition, the arteries are often calcified and special hardened microneedles are often required. Anastomoses should be performed away from the zone of injury, either proximal or distal to the zone of injury providing that the neurovascular bundle is intact. An end-to-side anastomosis to the recipient artery should be employed whenever possible two venous anastomoses are performed to minimize postoperative flap congestion.

The choice of free flap depends in large part on the length of pedicle needed. For long pedicles, the serratus, latissimus, vastus lateralis, rectus femoris and gracilis muscles are excellent. It is important to remember that the pedicle can be extended by further dissection within the muscle belly. For the dorsum of the foot and ankle, thin fasciocutaneous or cutaneous flaps work best. For the plantar foot, skin-grafted muscle flaps and skin graft seem to hold up better than fasciocutaneous flaps in the long run.

a. Microneurovascular Free Transfer of a Dorsalis Pedis Flap to the Heel
b. Free parietotemporalis Fascial Flap
c. Free Scapular Flap
d. Scapular and Parascapular Fasciocutaneous Flaps

e. Microneurovascular Skin and Osteocutaneous Free Radial Artery Flap
f. Radial foream fasciocutaneous flap
g. Anterolateral Thigh Fasciocutaneous Flap
h. Latissmus dorsi Myoplasty with split skin graft
i. Latissmus dorsi Myocutaneous Flap
j. Gracilis myoplasty with split skin graft
k. Lateral Arm Flap

RECONSTRUCTIVE OPTIONS BY LOCATION OF DEFECT

Dorsum of the Foot

The defects on the dorsum of the foot are often treated with simple skin grafts. If the tissue covering the extensor tendons is thin or nonexistent, a dermal regeneration template should be applied, and when vascularised, covered with a thin skin autograft. Local flaps that can be used for small defects include rotation, bilobed, rhomboid, or transposition flaps. The extensor digitorum brevis muscle flap works well for sinus tarsi defects and its reach can be increased by cutting the dorsalis pedis artery above or below tarsal artery, depending on the presence of antegrade and retrograde flow and the location of the defect. The supramalleolar flap can be used over the lateral proximal dorsal foot and its reach can be increased by cutting the anterior perforating branch of the peroneal artery before it anastomoses with the lateral malleolar artery. For larger or more distal defects, the most appropriate microsurgical free flap is a thin fasciocutaneous flap to minimize bulk. The radial forearm flap is an excellent choice because it is thin, sensate, and provides a vascularised tendon to reconstruct lost extensor function. Thin muscle or fascial flaps with skin grafts are effective options as well.

Forefoot Coverage

Toe ulcers and gangrene are best treated with limited amputations that preserve any viable tissue so that the amputated toe is as long as possible when closed. Attempts to preserve at least the proximal portion of the proximal phalanx should be made so that it can serve as spacer, preventing the toes on either side from drifting into the empty space. If the hallux is involved, attempts should be made to preserve as much as possible because of its critical role in ambulation.

Ulcers under the metatarsal head(s) occur because biomechanical abnormalities and place excessive or extended pressure on the plantar forefoot during the gait cycle. Although hammertoes, long metatarsals, or sesamoids can be contributing factors, the principal abnormal biomechanical force is a tight achilles tendon that prevents ankle dorsiflexion beyond the neutral position. If the patient cannot dorsiflex foot with the knee bent or straight, both the Gastrocnemius and soleus portions of the tendon are tight. In addition, the posterior capsule of the ankle joint may be tight. A percutaneous release of the achilles tendon is performed and if the foot still does not dorsiflex, then a posterior capsular release is performed. If the patient can dorsiflex foot only when the knee is bent, then the Gastrocnemius portion of the Achilles tendon is tight. A Gastrocnemius recession should correct the problem. With the release of the Achilles tendon, the forefoot pressure drops dramatically and the ulcer, if bone is not involved, heals simply by secondary intention in less than 6 weeks. The lengthening of a tight Achilles tendon has decreased the ulcer recurrence rate in diabetics by half at 2 years.

For patients with normal ankle dorsiflexion who have prominent metatarsal head, the affected metatarsal head can be elevated with preplanned osteotomies and internal fixation. The metatarsal head is shifted 2 to 3 mm superiorly. Upward movement with its attendant pressure relief is usually sufficient for the underlying ulcer to heal by secondary intention. The small, deep forefoot ulcers, without an obvious bony prominence, can be allowed to heal by secondary intention or with a local flap. For larger ulcers where the metatarsal head and distal shaft are involved, consideration should be given to a partial ray amputation. Resecting the more independent first or fifth metatarsal causes less biomechanical disruption than resecting the second, third, or fourth metatarsal because the central three metatarsals operate as a cohesive central unit.

All efforts should be made to preserve as much of the metatarsals as possible if more than one is compromised, because they are important to normal ambulation. Because local tissue is often insufficient to do this in the forefoot, a microsurgical free flap is considered. If ulcers are present under several metatarsal heads, or if a transfer lesion from one of the resected metatarsal heads to a neighboring metatarsal has occurred, a pan-metatarsal head resection should be considered. If more than two toes with the accompanying metatarsal heads have to be resected, then a transmetatarsal amputation should be performed. The normal parabola, with the resultant equines deformity from the loss of the long and short toe extensors, the extensor and flexor tendons of the fourth and fifth toe should be tenodesed with the ankle in the neutral position and the achilles tendon lengthened. As much plantar tissue as possible should be preserved to cover as much of the anterior portion of the amputation with healthy plantar tissue.

The most proximal forefoot amputation is the Lisfranc amputation where all the metatarsals are removed. The direction of the blood flow along the dorsalis pedis and lateral plantar artery should be evaluated. If both have antegrade flow, then the connection between the two can be sacrificed. However if only one of the two vessels is providing blood flow to the entire foot, the connection has to be preserved. To prevent an equinovarus deformity, the anterior tibial tendon should be split and the lateral aspect inserted into the cuboid bone. In addition, the Achilles tendon should be lengthened. The Lisfranc amputation can be closed with volar or dorsal flaps, if there is sufficient tissue. If there is inadequate tissue for coverage, a free muscle flap with skin graft is used. Postoperatively, the patient's foot is placed in slight dorsiflexion until the wound has healed.

Midfoot Coverage

Defects on the medial aspect of the sole are non-weight bearing and are best treated with a skin graft. Ulcers on the medial and lateral plantar midfoot are usually caused by Charcot collapse of the midfoot plantar arch. If the underlying shattered bone has healed and is stable, then the excess bone can be shaved via a medial or lateral approach while the ulcer either can be allowed to heal by secondary intention or can be covered with a glabrous skin graft or a local flap. For small defects, useful local flaps include the V-to-Y flap, the bilobed flap, the rhomboid flap, and the transposition flap. If a muscle flap is needed, a pedicled abductor hallucis flap medially or an abductor digiti minimi flap laterally works well. For slightly larger defects, large V-to-Y flaps, random, large, medially based rotation flaps or pedicled medial plantar fasciocutaneous flap can be successful. Larger defects should be filled with free muscle flaps covered by skin grafts. Great care should be taken to tailor the flap so that it is inset at the same height as the surrounding tissue. If the midfoot bones are unstable, then they can be excised using a wedge excision and the arch is recreated by fusing the proximal metatarsals to the talus and calcaneus via an Ilizarov frame. The shortening of the skeletal midfoot usually leaves enough loose soft tissue to close the wound primarily or with a local flap.

Hindfoot coverage

Plantar heel defects or ulcers are among the most difficult of all wounds to treat. If they are the result of the patient being in a prolonged decubitus position, they usually also reflect severe vascular disease. A partial calcanectomy may be required to develop enough local soft tissue to cover the resulting defect. Although patients can ambulate with a partially resected calcaneum, they will need orthotics and molded shoes.

If there is an underlying collapsed bone or bone spur causing a hindfoot defect, the bone should be shaved. These ulcers are usually closed with a large, distally based V-to-Y flap, or larger medially based rotation flaps. Plantar heel defects can also be closed with pedicled flaps that include the medial plantar fasciocutaneous flap or the flexor digiti minimi muscle flap. Posterior heel defects are better closed with an extended lateral calcaneal fasciocutaneous flap or the retrograde sural artery fasciocutaneous flap. If the defect is large, then a muscle free flap with skin graft should be used. The flap should be carefully tailored so there is no excess tissue and it blends well with the rest of heel. Medial or lateral calcaneal defects usually occur after fracture and attempted repair. There is usually associated osteomyelitis of the calcaneum. After debridement of the infected bone and placement of antibiotic beads, the medial defect can usually be covered with the abductor hallucis muscle flap medially or the abductor digiti minimi flap laterally. The exposed muscle is then skin grafted.

The two hindfoot amputations are the Chopart and Symes amputataions. The Chopart amputation leaves an intact talus and calcaneus while removing the mid and forefoot bones of the foot. To avoid going into equinovarus deformity, a minimum of 2 cm of the Achilles tendon has to be resected. When healed, a calcaneal – tibial rod can be used to further stabilize the ankle. The Symes amputation should be considered if there is insufficient tissue to primarily close a Chopart amputation and there is insufficient arterial blood supply for a free flap, or if the talus and calcaneus are involved with osteomyelitis. The tibia and fibula are cut just above the ankle mortise and the heel pad is anchored to the anterior portion of the distal tibia. The large medial and lateral dog-ears can be carefully trimmed at the initial operation or 4 to 6 weeks later to yield a thin, tailored stump that can fit well into a weight-bearing prosthesis.

MATERIALS AND METHODS

Study Design

This is a prospective study conducted on 60 patients with soft tissue injury to foot involving the dorsum and sole.

Place and duration of study

The study was conducted in Department of Plastic Surgery at Government Rajaji Hospital, Madurai through a period of two years and four months – November 2006 to February 2009.

Patients and Methods

Over a period of 2 yrs 4 months 60 patients were studied.

In this study etiology of the defect, region of foot involved, age group commonly affected, type of skin cover were analysed. Pre-operative work up done to rule out uncontrolled diabetes, hypertension and sepsis. Injury/pathology to underlying tendon or bone was evaluated. Patients with a tissue defect of foot due to injury / infection/ vascular disorder were stabilized initially, underlying cause controlled, wound swab done, antibiotics given. These patients were referred after all this from corresponding department, once wound was fit for cover, secondary reconstruction done.

Patients with carcinoma of foot were evaluated, metastatic work up done by team of surgical oncologist. Primary reconstruction done after wide local excision.

Inclusion criteria

1. Patients with exclusive foot injuries and sequelae.
2. Soft tissue defect with stabilized bone injury.
3. All age groups.
4. Tissue defect due to trauma, burns, infection, tumor, vascular disorders.
5. Wound with controlled infection
6. Abstinence from smoking 3 weeks prior to procedure.

Exclusion criteria

1. Injury to other parts of lower limb.
2. Uncontrolled DM/HT/Sepsis
3. Wound with infection
4. Raw area with vascular compromise

Type of cover, take of graft, survival of flap were assessed. Duration of hospital stay for each procedure analysed. On follow up, sensation and pliability of cover, complication, cover dehiscence and rate of contracture assessed.

Average follow up of patients were for 6 months.

Statistical analysis

The entire data was analyzed using Statistical product and service solution software.

OBSERVATION

The following are results of the study done between November 2006 to February 2009

AGE AND SEX INCIDENCE

Of the 60 cases, 44 occurred in males and 16 occurred in females. Male to female ratio is 2.7:1. Soft tissue of foot are more common in 31-40 years of age group accounting for 31.11% of the cases in our study.

Table 1

AGE INCIDENCE

Age	No. of cases	Percentage
<10	09	15%
11-20	04	6.6%
21-30	10	16.6%
31-40	20	33.3%
41-50	06	10%
51-60	08	13.3%
>60	O6	10%

Table 2

SEX INCIDENCE

Sex	No. of cases	Percentage
Male	44	73.3%
Female	16	26.6%

AETIOLOGY OF THE SOFT TISSUE DEFECT

Trauma accounts for the major cause of soft tissue defect of foot involving 30 cases (50%), with next on ladder being the post burns raw area and contracture involving 14 cases (23.3%.)

Aetiology	No. of cases	Percentage
Post traumatic	30	50%
Post burns	14	23.3%
Post tumor	8	13.3%
Post infective	4	6.6%
Chronic Venous ulcer	3	3.3%
Diabetic ulcer	1	1.6%

ANATOMICAL SITE OF THE DEFECT

The soft tissue defects of foot were classified into dorsum and sole of foot. In this study, the predominant area to be involved was dorsum, followed by sole.

Site	No. of cases	Percentage
Dorsum	42	70%
Sole	18	30%

Mode of reconstruction

Split thickness skin grafting was done for 38 cases (71%) and flap cover was given for 22 cases (29%)

Type	No. of cases	Percentage
SSG	38	71%
Flap	22	29%

TYPE OF FLAP COVER

The following flap covers were given

Reverse sural artery flap was the predominant cover used in our reconstruction, followed by lateral fasciocutaneous perforator flap, propeller and free flap.

Flap	**No.of Cases**	**Percentage**
Reverse Sural Artery Flap	16	26.6
Lateral Fasciocutaneous Perforator Flap	4	6.6
Propeller Flap	1	1.6
Latissmus Dorsi Free Flap	1	1.6

Split Skin Graft

SSG was done in 39 patients. Etiology included predominantly road traffic accident 21 patients, post burn raw area about 10 cases. Other cases included post infective raw area due to snake bite cellulitis and necrotizing fasciitis, 3 cases of varicose ulcer were also done.

Etiology	No.of patients
Road Traffic Accident	21
Burn	10
Snake Bite	3
Varicose Ulcer	3
Necrotising Fasicitis	1

Split skin grafting done for soft tissue defect dorsum of foot (31 patients). Sole of foot included (8 patients), cause of defect being road traffic accident.

Region of Foot	No.of Patients
Dorsum	31
Sole	8

<u>Reverse Sural Artery flap</u>

RSA flap was done in 16 of our patients. All 8 patients with squamous cell carcinoma of sole received this flap, six patients with raw area exposing underlying tendon / bone covered, 2 cases of post burn sequalae causing contracture were released and covered with RSA flap.

Etiology	No. of Patients
SCC	8
RTA	6
PBS	2

Lateral Fasciocutaneous Flap

Lateral fasciocutaneous flap were done in four patients of which 3 patients were RTA and one was PBS.

Etiology	No. of Patients
RTA	3
PBS	1

Propellar Flap

This flap cover was done for one case of post traumatic raw area dorsum of foot. Perforator from lateral aspect of leg confirmed with Doppler.

Free Flap

Latissmus dorsi myoplasty with SSG done to one case of metatarsal fracture stabilized with K-wire with and raw area dorsum of foot.

DISCUSSION AND ANALYSIS

Age and Sex incidence:

1. Male population was majority in our study (44), followed by female (16) patients.
2. Age group at the 21 to 40 years who were home maker (or) bread winner group of the family subjected to problem.
3. Children less than 10 years of age constituted significantly next higher group.
4. Middle age group people were about 8 patients subjected to reconstruction of foot, considerably causing morbidity due to prolonged stay.

ETIOLOGY

Analyzing the etiology of soft tissue defect of foot

1. Road traffic accident formed the predominant cause, which was due to motor vehicle. Age group between 21-40 travelled more compared to other group for food and living, so were prone to road traffic accident in our part of the town with irregular traffic.

2. Burns raw area constituted next major cause of raw area foot though majority of the burns involving significant trunk of the body, burns raw area restricted to foot were selected.
3. The cause for burns raw area were accidental flame burns / scalds while cooking.
4. In 8 cases, squamous cell carcinoma of heel was the cause of heel defect in this study. Tumor was excised by the oncosurgeons, defect was reconstructed with flap cover. Other tumors of foot were not encountered during the study period.
5. Infection was also a cause of raw area, 2 cases of snake bite causing cellulitis, which was treated and debrided later due to sloughing of skin. One case was necrotising fascitis, which was debrided, infection controlled and skin cover was given.
6. Three cases of venous ulcer over the dorsum of foot were covered after varicose vein disease was corrected by the vascular surgeon.

ANATOMIC SITE OF DEFECT

Dorsum of foot

This was the major affected area, cause being trauma, followed by burns and burns sequalae. People walk with chappals in our part of town, more prone for insect and rodent bites. We had four case of post infective raw area over dorsum for which skin cover was given.

Sole of Foot

Of the eighteen cases, eight cases was due to squamous cell carcinoma of the heel. All the other ten cases being road traffic accidents, with tissue defect of entire sole of foot (or) degloving injury with necrosis of part of soft tissue.

Type of Reconstruction

Reconstruction was tailored according to the defect location and underlying structures.

This is analyzed under following subheading to for the type of reconstruction.

a) Type of procedure
b) Graft take / Flap survival

c) Hospital stay
d) On follow up – sensation,
   pliability and contracture

SPLIT SKIN GRAFT

SSG was done in thirty nine patients. All cases of post burn raw area, varicose ulcer, post infective raw area like necrotizing fascitis and snake bite cellulitis received SSG after debridement and control of infection. Twenty two patients of road traffic accidents with soft tissue injuries of foot received SSG.

Aetiology	**No. of patients**
1. Burns	10
2. Snake bite	3
3. Necrotizing fascitis	1
4. Road Traffic Accident	2
5. Varicose Ulcer	3

Split skin graft was predominantly done for the dorsum of foot in thirty one patients. Ten patients with soft tissue injuries involving the sole of foot also received SSG.

Graft Take:

In non infective cases SSG take was 100%. In infective cases like necrotizing fascitis and snake bite the graft take was 95% the mean graft take was 99.23%.

Graft Take

Non infective cause	100%
Snake bite	95
Necrotizing fascitis	90%

Hospital Stay

The mean duration of hospital stay in the patients who underwent SSG was 9.35 days taking into account from the date of surgery. The duration of hospital stay was more in patients with infective raw area like necrotizing fascitis and snake bite cellulitis - the average duration being twelve days.

Sensation:

The sensation was almost intact in five patients (12.82%). It was predominantly impaired in thirty two patients (82.5%) and absent in two patients coming to 5.13%.

Skin graft applied to sole of foot had protective impaired sensation.

Sensation	No. of Patients	Percentage
Intact	5	12.82%
Impaired	32	82.5%
Absent	2	5.13%

Pliability

Among all the patients who received split skin graft, 76.92% had pliability graft skin at the end of 6 months follow up. The patients whose graft skin was not pliable, snake bite cellulitis and necrotizing faciaties.

Pliability	Percentage
Infective	23.8%
Non – Infective	76.92%

Contracture

On average 7.6% of patients developed contracture that was in non pliable graft skin. The incidence of contracture was high in infective cases of raw area probably due to subtle infection in the wound.

REVERSE SURAL ARTERY FLAP

RSA flap was done in sixteen of our patients. All the eight patients with squamous cell carcinoma of the heel underwent RSA flap cover. Four patients of road traffic accident and two patients of Post burn sequelae received RSA flap.

Etiology	Patients
1) Squamous Cell Carcinoma	7
2) Road Traffic Accident	4
3) Post Burn Sequelae	2

Flap survival:

Flap survival was assessed. It was maximum for post burn sequelae and road traffic accident cases. It was minimum for Squamous Cell Carcinoma cases. The mean flap survival rate was 84.83%. The cause being due to relatively poor pliability of the heel tissue along with bulkiness of the flap due to more subcutaneous fat.

Hospital stay:

The mean duration of hospital stay was 24.8 days. The duration of hospital stay was prolonged in squamous cell carcinoma patients with decreased flap survival.

Sensation:

The sensation was absent in all cases due to insensate flap.

Pliability:

All cases of RSA flap cover were pliable but bulky.

Contracture:

There was no evidence of contracture in any of the patients.

LATERAL PERFORATOR BASED FASCIOCUTANEOUS FLAB

This flap was done in four patients, of which three patients were with soft tissue defect of dorsum of foot due to road traffic accident. One patient was due to contracture following healing of burns wound.

Flaps survival:

Flap uptake for 100% with no infection or dehiscence

Hospital Stay:

The average duration of hospital stay was comparatively low – sixteen days

Pliability:

The flap was thin compared to reverse sural artery flap. It was pliable and matched with the contour of the dorsum foot.

PROPELLER FLAP

This was done for one case. The flap take was 100%, with no evidence of post operative flap complication. Average duration of stay eighteen days from the day of procedure, this was predominantly to assess the take of the graft to the donor site.

The flap was thin and pliable but sensation was absent. There was no evidence of contracture on follow up.

FREE FLAP

Latissmus dorsi myoplasty with SSG, was done for one case with soft tissue defect dorsum of foot. Flap take was 98%. The average duration of stay in hospital was twenty five days. The flap was bulky but pliable, sensation was absent. There was no evidence was contracture on follow up.

COMPARISON OF SKIN GRAFT AND FLAP

In our analysis we compared take of the graft / flap, the duration of hospital stay, the pliability and sensation. SSG had a better role in reconstruction of soft tissue defect foot with correct indications (p value = 0.0023) than a flap cover. Thin flaps blend well with the contour of foot and survival is also good. Bulky flaps like reverse sural artery flap and Latissmus dorsi myoplasty with SSG had a comparatively longer morbidity. (p value = 0.072). Sensation was better with skin grafts than flap cover (p value = 0.012). Pliability is much better with all flaps (p value = 0.003) compared skin graft (p value = 0.010).

DRAWBACKS OF THE STUDY

1. Sensate flap was not done to the defect sole of foot
2. Number of patients who underwent thin flap was small (6) compared to skin graft (39) this will give a statistical bias.
3. Follow up of patients was for an average of 6 months, hence long term applicability of graft / thin flap could not be analyzed.

CONCLUSION

1. Split skin graft gives a reliable, pliable cover and acceptable sensation to raw area dorsum of foot without exposed tendon/ bone.
2. In injuries with exposed/ injured tendon or bone dorsum of foot, thin skin flap gives good functional outcome and aesthetic appearance.
3. Reverse sural artery flap was a bulky flap requiring secondary thinning, hence cannot used as one stage cover for tissue defect dorsum of foot.
4. The sole of foot, split skin grafting is acceptable in non-weight bearing area.
5. In weight bearing area sole of foot sensate flap is preferred.

SPLIT SKIN GRAFT
DORSUM FOOT

SPLIT SKIN GRAFT DORSUM OF FOOT

REVERSE SURAL ARTERY FLAP SOLE

REVERSE SURAL ARTERY FLAP
SOLE

PROPELLER FLAP

REVERSE SURAL ARTERY FLAP

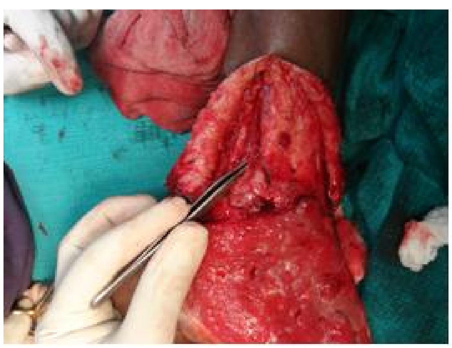
DORSUM

SPLIT SKIN GRAFT SOLE OF FOOT

SPLIT SKIN GRAFT SOLE OF FOOT

LATERAL FASIOCUTANEOUS FLAP

FREE FLAP – LATISSMUS DORSI MYOPLASTY WITH SSG



BIBLOGRAPHY

1. Free microvascular muscle flaps with skin graft reconstruction of extensive defects of the foot: a clinical and gait analysis study May JW Jr, Halls MJ, Simon SR
2. The distally based sural flap for lower leg reconstruction: versatility in patients with associated morbidity.Mileto D, Cotrufo S, Cuccia G, Delia G, Risitano G, Colonna MR, d'Alcontres FS.
3. The distally based sural flap for lower leg reconstruction: versatility in patients with associated morbidity.Mileto D, Cotrufo S, Cuccia G, Delia G, Risitano G, Colonna MR, d'Alcontres FS.
4. Reconstruction with microvascular flaps. PhDGünter Germann and MDDetlev Erdmann. Department of Plastic and Hand Surgery, Burn Center, B-G Trauma Center, Ludwigshafen, Germany.
5. Risk analysis for the reverse sural fasciocutaneous flap in distal leg reconstruction. Parrett BM, Pribaz JJ, Matros E, Przylecki W, Sampson CE, Orgill DP. Plast Reconstr Surg. 2009 May;123(5):1499-504

6. Free microvascular rectus abdominis muscle flap for soft tissue reconstruction of the lower leg and foot: results and donor site defect]Geishauser M et al. Handchir Mikrochir Plast Chir. (1999)
7. Application of distal peroneal perforator-based superficial peroneal neurofasciocutaneous flap for repairing donor site defect of forefoot] Li Z, Xiao C, Yin J, Chai Y. Department of Orthopaedics, the Central Hospital of Xinwen Mining Industry Group Companies, Taian Shandong, 271233, P.R. China.
8. Long-term follow-up on microsurgical free-tissue transfer in foot and ankle reconstruction. Musharafieh R, Wehbe J, Maalouf G, Atiyeh B. Foot Ankle Surg. 2008;14(2):82-8. Epub 2008 Jan 3.
9. Reconstruction of soft tissue defect of lower extremity with free SCIA/SIEA flap. Nasir S, Aydin MA. Ann Plast Surg. 2008 Dec;61(6):622-6.
10. Soft tissue defects of the heel: a surgical reconstruction algorithm based on a retrospective cohort study. El-Shazly M, Yassin O, Kamal A, Makboul M, Gherardini G. Department of Plastic Surgery, Assiut University Hospital, Assiut, Egypt. moh.elshazly@lycos.com.

11. Grab and Smith 6th Edition, Text Book of Plastic Surgery–Reconstruction of Foot.

12. Heel coverage using a distally based sural artery fasciocutaneous cross-leg flap: report of a small series. Basile A, Stopponi M, Loreti A, Minniti de Simeonibus AU. J Foot Ankle Surg. 2008 Mar-Apr;47(2):112-7.

13. Experience with the distally based sural neurofasciocutaneous flap supplied by the terminal perforator of peroneal vessels for ankle and foot reconstruction. Chai Y, Zeng B, Zhang F, Kang Q, Yang Q. Ann Plast Surg. 2007 Nov;59(5):526-31.

14. Reconstruction of diabetic foot ulcers by lateral supramalleolar flap. Yercan HS, Ozalp T, Okcu G. Saudi Med J. 2007 Jun;28(6):872-6.

15. Instep free flap for plantar soft tissue reconstruction: indications and options. Scheufler O, Kalbermatten D, Pierer G. Microsurgery. 2007;27(3):174-80.

16. Reverse sural artery flap for distal lower extremity defects. Savk O, Savk E. J Dermatol. 2006 Oct;33(10):700-4.

17. Reconstruction of crush injuries of the foot dorsum: is the latissimus dorsi muscle flap a reliable choice? Uluçay GE, Yildirim S, Aydoğdu E, Aköz T. J Reconstr Microsurg. 2006 Apr;22(3):157-66.
18. Functional total and subtotal heel reconstruction with free composite osteofasciocutaneous groin flaps of the deep circumflex iliac vessels. Peek A, Giessler GA. Ann Plast Surg. 2006 Jun;56(6):628-34.
19. Clinical application of the distally based sural island flap and myofasciocutaneous flap] Shen Y, Xiang D, Wang N, Mi H, Tan F, Chen H, Shen Z. Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi. 2006 Mar;20(3):256-8. Chinese. M. Taifour uliman, MD, FRCS, Consultant Plastic & Burns Surgeon, King Khalid Civilian Hospital, PO Box 876, Tabuk, Kingdom of Saudi Arabia. Consultant Plastic & Burns Surgeon, King Khalid Civilian Hospital, Tabuk, Kingdom of Saudi Arabia.
20. Jolly GP, Zgonis T. Pedicle flaps for replacement of soft tissue defects of the foot. Chir del piede. 2003;27:1-10.

21. Mathes Text Book of Plastic Surgery, Volume V – Reconstruction of Foot.
22. Jolly GP, Zgonis T, Blume P. Soft tissue reconstruction of the diabetic foot. Clin Podiatr Med Surg. 2003;20:757-781.
23. Nakajima H, Imanishi N, Fukuzumi S, et al. Accompanying arteries of the lesser saphenous vein and sural nerve: anatomic study and its clinical applications. Plast Reconstr Surg. 1999;103:104-120.
24. Yilmaz M, Karatas O, Barutcu A. The distally based superficial sural artery island flap: clinical experiences and modifications. Plast Reconstr Surg. 1998;102:2358-2367.
25. Donski PK, Fogdestam I. Distally based fasciocutaneous flap from the sural region: a preliminary report. Scand J Reconstr Surg. 1983;17:191-196.
26. Hasegawa M, Torii S, Katoh H, Esaki S. The distally based superficial sural artery flap. Plast Reconstr Surg. 1994;93:1012-1020.
27. Jeng SF, Wei FC. Distally based sural island flap for foot and ankle reconstruction. Plast Reconstr Surg. 1997;99:744-750.

28. Coskunfirat OK, Velidedeoglu HV, Sahin U, Demir, Z. Reverse neurofasciocutaneous flaps for soft-tissue coverage of the lower leg. Ann Plast Surg. 1999;43:14-20.
29. Ferreira AC, Reis J, Pinho C, Martins A, Amarante J. The distally based island superficial sural artery flap: clinical experience with 36 flaps. Ann Plast Surg. 2001;46:308-313.
30. Almeida MF, Robero da Costa P, Okawa RY. Reverse flow island sural flap. Plast Reconstr Surg. 2002;109: 583-591.
31. Singh S, Naasan A. Use of distally based superficial sural island artery flaps in acute open fractures of the lower leg. Ann Plast Surg. 2001;47:505-510.
32. Al-Qattan MM. A modified technique for harvesting the reverse sural artery flap from the upper part of the leg: inclusion of a gastrocnemius muscle "cuff" around the sural pedicle. Ann Plast Surg. 2001;47:269-278.
33. Isenberg JS. When less is more: revascularization and sural artery fasciocutaneous flaps in ischemic limb salvage. J Reconstr Microsurg. 2003;19:235-240.

34. Raveendran SS, Perera D, Happuharachchi T, Yoganathan V. Superficial sural artery flap - a study in 40 cases. Br J Plast Surg. 2004;57(3):266-269.
35. Sharma GN, Nepram SS. Sural artery flap: a dependable solution in lower leg and foot soft tissue reconstruction. Int Surg. 2001;86(3):144-150.
36. Grabb encyclopedia of flaps – Volume III – Reconstruction of foot.
37. Rashid M, Hussain SS, Aslam R, Illahi I.A comparison of two fasciocutaneous flaps in the reconstruction of defects of the weight-bearing heel. J Coll Physicians Surg Pak. 2003;13(4):216-218.
38. Angel MF, Ramasastry SS, Swartz WM, Basford RE , Futrell JW. The causes of skin ulcerations associated with venous insufficiency: a unifying hypothesis. Plast Reconstr Surg. 1987;79:289-297
39. Medial plantar perforator flaps with supermicrosurgery. Koshima I, Nanba Y, Tsutsui T, Takahashi Y. Clin Plast Surg. 2003 Jul;30(3):447-55, vii
40. [Endoscopically-assisted latissimus dorsi muscle harvest in a young child] Schoeller T, Huemer GM, Otto-Schoeller A, Wechselberger

G, Piza-Katzer H. Handchir Mikrochir Plast Chir. 2003 Jul;35(4):259-62. German

41. [Endoscopically-assisted latissimus dorsi muscle harvest in a young child] Schoeller T, Huemer GM, Otto-Schoeller A, Wechselberger G, Piza-Katzer H. Handchir Mikrochir Plast Chir. 2003 Jul;35(4):259-62. German

42. The role of plastic and reconstructive surgery within an interdisciplinary treatment concept for diabetic ulcers of the foot] Baumeister S, Dragu A, Jester A, Germann G, Menke H. Dtsch Med Wochenschr. 2004 Mar 26;129(13):676-80. German.

43. An experience with free scapular flap for reconstruction of lower extremity defects at Aga Khan University Hospital Karachi. Hashmi PM. J Ayub Med Coll Abbottabad. 2004 Jan-Mar;16(1):54-7.

44. One-stage reconstruction of composite bone and soft-tissue defects in traumatic lower extremities. Yazar S, Lin CH, Wei FC. Plast Reconstr Surg. 2004 Nov;114(6):1457-66.

45. Clinical applications of free soleus and peroneal perforator flaps. Kawamura K, Yajima H, Kobata Y, Shigematsu K, Takakura Y. Plast Reconstr Surg. 2005 Jan;115(1):114-9.
46. [The serratus anterior free flap in limb reconstruction. About 30 cases] Duteille F, Waast D, Perrot P, Cronier P, Hubert L, Pannier M. Ann Chir Plast Esthet. 2005 Feb;50(1):71-5. French
47. [The serratus anterior free flap in limb reconstruction. About 30 cases] Duteille F, Waast D, Perrot P, Cronier P, Hubert L, Pannier M. Ann Chir Plast Esthet. 2005 Feb;50(1):71-5. French
48. Deep inferior epigastric perforator flap for foot reconstruction using an external pedicle. Masuoka T, Nomura S, Yoshimura K, Ohmori K. J Reconstr Microsurg. 2005 May;21(4):231-4

49. Reconstruction of heel defects with a proximally based abductor hallucis muscle flap. Ortak T, Ozdemir R, Ulusoy MG, Tiftikcioglu YO, Karaaslan O, Kocer U, Sensoz O. J Foot Ankle Surg. 2005 Jul-Aug;44(4):265-70

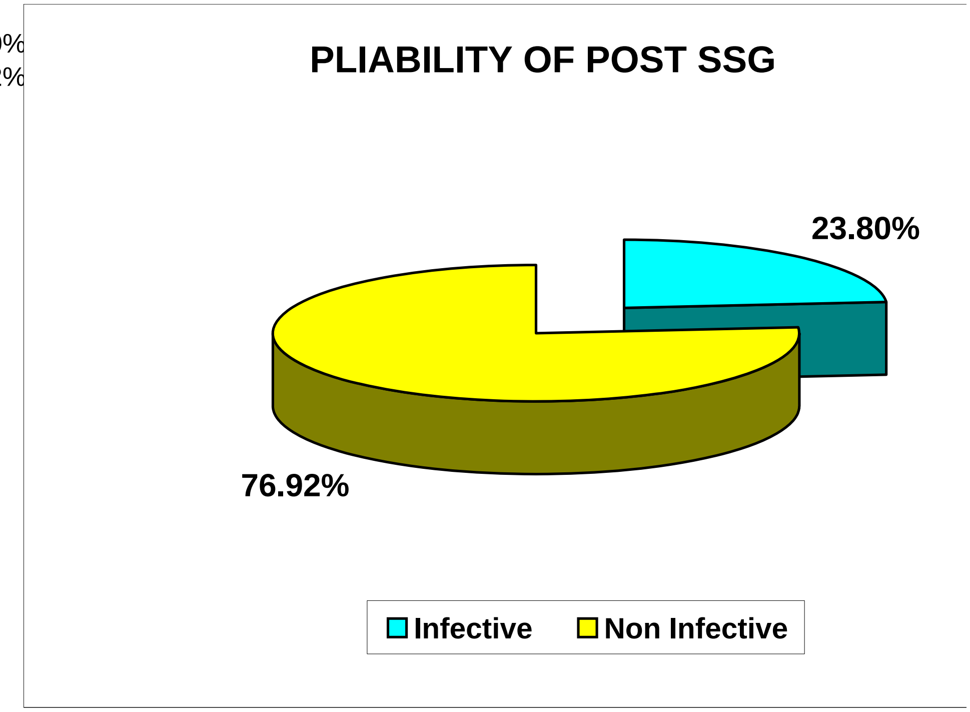
50. Resection and reparation of heel with malignant melanoma] Zhang Q, Wang Y, Liang Y. Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi. 2005 Jul;19(7):536-8. Chinese.
51. Modified distally based sural neuro-veno-fasciocutaneous flap: anatomical study and clinical applications. Zhang FH, Chang SM, Lin SQ, Song YP, Zheng HP, Lineaweaver WC, Zhang F. Microsurgery. 2005;25(7):543-50
52. Combined vascular reconstruction and free flap transfer in diabetic arterial disease. Vermassen FE, van Landuyt K. Diabetes Metab Res Rev. 2000 Sep-Oct;16 Suppl 1:S33-6
53. The use of local muscle flaps in foot and ankle reconstruction. Attinger CE, Ducic I, Zelen C. Clin Podiatr Med Surg. 2000 Oct;17(4):681-711. Review
54. Cross-foot island instep flap: a new use of instep skin flap for management of persistent wounds after complex plantar foot reconstruction. Nişanci M, Celiköz B, Duman H. Ann Plast Surg. 2001 Aug;47(2):127-33.

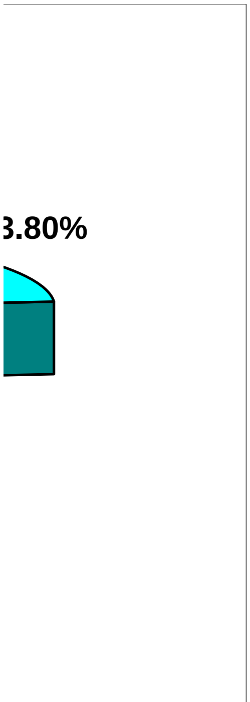
55. Pedicled foot fillet flap based on the tibialis anterior vessels: case report. Cavadas PC, Bakliñska MI, Soler S, Navarro A. J Reconstr Microsurg. 2002 Feb;18(2):87-9.

56. Clinical application of sural nerve island flap pedicled with collateral vessels] Pei B, Hu JH, Li DS. Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi. 2000 Jul;14(4):223-5. Chinese

57. Evaluation of sensitivity in the fasciocutaneous neurovascular medial plantar island flap in reconstruction of soft tissue defects in the calcaneal region] Jevtović D. Vojnosanit Pregl. 2002 Jul-Aug;59(4):399-404. Serbian.

Infective	23.80%
Non Infecti	76.92%




3.80%

MASTER CHART

S.no	Age	Sex	Etiology	Region of foot	Type of Procedure	Graft Take	Flap Survival	Hospital Stay in days	Follow up	on Follow up		
										Sensation	Pliability	Contracture
1	28	M	Varicose Ulcer	Dorsum	SSG	100%	-	9	6	Impaired	+	No
2	5	M	RTA	Dorsum	RSA	-	100%	22	10	Ab	+	No
3	3	M	Burns	Dorsum	SSG	100%	-	8	7	Intact	-	-
4	15	M	RTA	Dorsum	SSG	100%	-	10	12	Impaired	+	Yes
5	49	M	SCC	Sole	RSA	-	80%	29	8	Ab	+	No
6	29	M	Varicose Ulcer	Dorsum	SSG	100%	-	8	3	Impaired	+	No
7	36	F	SCC	Sole	RSA	-	70%	29	2	Ab	+	No
8	39	F	SCC	Sole	RSA	-	100%	20	8	Ab	+	No
9	16	M	RTA	Dorsum	SSG	100%	-	11	14	Intact	+	No
10	25	F	PBS	Dorsum	LFC	-	100%	21	8	Ab	+	No
11	31	M	RTA	Dorsum	SSG	100%	-	12	7	Impaired	+	No
12	18	M	Snake Bite	Dorsum	SSG	95%	-	13	8	Impaired	-	Yes
13	40	M	NF	Dorsum	SSG	90%	-	14	9	Impaired	-	Yes
14	26	M	PBS	Sole	SSG	100%	-	10	10	Impaired	+	No
15	17	M	PBS	Dorsum	RSA	-	100%	20	3	Impaired	+	No
16	3	M	SB	Dorsum	SSG	90%	-	15	4	Ab	+	No
17	4	M	RTA	Sole	SSG	100%	-	11	5	Impaired	-	No
18	29	F	RTA	Sole	SSG	100%	-	9	11	Impaired	+	No
19	24	F	RTA	Dorsum	RSA	-	95%	30	9	Ab	+	No
20	29	M	RTA	Dorsum	SSG	100%	100%	8	8	Impaired	+	No
21	42	M	Burns	Dorsum	SSG	100%	-	9	4	Impaired	+	No
22	22	M	RTA	Dorsum	LFC	-	100%	19	7	Ab	+	No
23	38	F	Burns	Dorsum	SSG	100%	-	8	9	Impaired	+	No
24	21	M	RTA	Dorsum	LFC	-	100%	16	6	Ab	+	No
25	37	F	SCC	Sole	RSA	-	90%	28	8	Ab	+	No
26	72	M	RTA	Dorsum	SSG	100%	-	9	5	Intact	-	No
27	35	M	Burns	Dorsum	SSG	100%	-	9	1	Intact	-	Yes
28	69	M	RTA	Dorsum	SSG		-	11	3	Impaired	+	No
29	5	M	SCC	Sole	RSA	100%	80%	28	5	Ab	+	No
30	49	F	Burns	Dorsum	SSG	100%	-	10	4	Impaired	+	Yes
31	39	F	PBS	Sole	SSG	100%	-	9	7	Impaired	-	No
32	2	M	RTA	Dorsum	LFC	-	100%	20	6	Ab	+	No

33	50	F	Burns	Dorsum	SSG	100%	-	10	1	Impaired	+	No
34	32	M	RTA	Dorsum	Proellar	-	100%	18	9	Ab	+	No
35	35	M	RTA	Sole	SSG	100%	-	9	7	Impaired	+	No
36	3	F	RTA	Dorsum	LD MP + SSG	-	100%	23	6	ab	+	No
37	31	M	RTA	Dorsum	SSG	100%	-	8	3	Impaired	+	No
38	4	M	RTA	Dorsum	SSG	100%	-	10	4	Intact	+	No
39	9	M	RTA	Sole	SSG	100%	-	10	5	Impaired	+	No
40	45	M	RTA	Sole	SSG	100%	-	11	12	Impaired	+	No
41	43	M	Burns	Dorsum	SSG	100%	-	9	9	Impaired	+	No
42	63	M	RTA	Dorsum	RSA	-	80%	32	7	Ab	+	No
43	49	M	Varicose Ulcer	Dorsum	SSG	100%	-	8	2	Impaired	+	No
44	40	F	SCC	Sole	RSA	-	80%	32	4	Ab	+	No
45	53	M	SCC	Sole	RSA	-	100%	20	6	Ab	+	No
46	52	M	SCC	Sole	RSA	-	100%	22	9	Ab	+	No
47	51	M	Burns	Dorsum	SSG	100%	-	9	7	Impaired	+	No
48	32	F	Burns	Dorsum	SSG	100%	-	13	8	Impaired	+	No
49	39	M	Burns	Dorsum	SSG	100%	-	10	2	Impaired	+	No
50	70	M	Snake Bite	Dorsum	SSG	90%	-	9	4	Impaired	+	No
51	34	F	RTA	Dorsum	SSG	100%	-	10	8	Impaired	+	No
52	61	M	RTA	Dorsum	SSG	100%	-	10	2	Intact	+	No
53	35	F	RTA	Dorsum	SSG	100%	-	9	3	Impaired	+	No
54	69	F	RTA	Dorsum	RSA	-	80%	32	6	Impaired	+	No
55	36	M	RTA	Dorsum	SSG	100%	-	9	2	Ab	+	No
56	37	M	RTA	Dorsum	SSG	100%	-	8	3	Intact	+	No
57	38	M	PBS	Dorsum	CLF	-	100%	30	4	Intact	+	No
58	39	M	RTA	Dorsum	SSG	100%	-	14	4	Ab	+	No
59	72	M	RTA	Sole	SSG	100%	-	12	6	Impaired	-	No
60	75	M	RTA	Sole	SSG	100%	-	11	7	Impaired	-	No

SCC - Squamous cell Carcinoma
PBS - Post Burn Sequelae
RTA - Road Traffic Accident
NF - Necrotising Fascitis
AB - Absent